Coupled charge and valley excitations in graphene quantum Hall ferromagnets(Topological Aspects of Solid State Physics)

Shibata, Naokazu

DAY 2: 13:30 – 14:10

Coupled charge and valley excitations in graphene quantum Hall ferromagnets

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Graphene is a two-dimensional carbon material with a honeycomb lattice and Dirac-like low-energy spectrum. In a strong magnetic field, where Coulomb interactions dominate against disorder broadening, quantum Hall ferromagnetic states realize at integer fillings. Extending the quantum Hall ferromagnetism to the fractional filling case of massless Dirac fermions, we study the elementaly charge excitations which couple with the valley degrees of freedom (so called valley skyrmions). With the use of the density matrix renomalization group (DMRG) method, the excitation gaps are calculated and extrapolated to the thermodynamic limit. These results exhibit numerical evidences and criterions of the skyrmion excitations in graphene

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DAY 2: 14:10 – 14:50

Band touching from real space topology in frustrated hopping models

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(with Doron L. Bergman, Congjun Wu)

"Accidental" band touchings, such as the Dirac point in graphene, can be protected by topology. Many cases similar to graphene exist, and are well understood to arise from the momentum space topology of Bloch states. A different situation arises in "frustrated" hopping models, in which at least one energy band, at the maximum or minimum of the spectrum, is dispersionless. The states of the flat band(s) can be represented in a basis which is fully localized, having support on a vanishing fraction of the system in the thermodynamic limit. In the majority of examples, a dispersive band touches the flat band(s) at a number of discrete points in momentum space. We demonstrate that this band touching is related to states which exhibit non-trivial topology in *real space*. Specifically, these states have support on one-dimensional loops which wind around the entire system (with periodic boundary conditions). A counting argument is given that determines, in each case, whether there is band touching or not, in precise correspondence to the result of straightforward diagonalization. When they are present, the topological structure protects the band touchings in the sense that they can only be removed by perturbations which *also* split the degeneracy of the flat band.